

Appl. No. 10/840,095
Amdt. dated 01/13/2007
Response to Office Action of 10/17/2006

Attorney Docket No.: N1085-00288
[TSMC2004-0032]

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings of claims in the application:

- 1 1. (Currently Amended) A method of depositing a metal layer on a wafer, the
2 method comprising:
3 immersing the wafer in an electrolytic solution containing metal ions; and
4 biasing the wafer negatively with respect to the electrolytic solution so as to
5 create a current flow between the electrolytic solution and the wafer and thereby
6 electroplate a metal layer on a surface of the wafer in a continuous electroplating
7 operation that continuously deposits the metal layer on the surface by first biasing the
8 wafer to produce a first current density, then secondly biasing the wafer to produce a
9 second current density, the second current density being greater than zero and less
10 than the first current density, then thirdly biasing the wafer to produce a third current
11 density, the third current density being greater than the first current density, and the first
12 biasing being the initial step in the continuous electroplating operation.
- 1 2. (Currently Amended) The method as in claim 1, wherein ~~the biasing the wafer~~
2 ~~further includes, after the secondly biasing, thirdly biasing the wafer to produce a third~~
3 ~~current density, the third current density being greater than the second current density is~~
4 no longer used.
- 1 3. (Cancelled)
- 1 4. (Currently Amended) The method as in claim ~~[[3]]~~ 1, wherein the biasing the
2 wafer negatively includes, after the thirdly biasing, further electroplating using a
3 succession of steps of increasing current densities, the succession of steps beginning
4 with a fourth step having a fourth current density being greater than the third current
5 density.

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- 1 5. (Original) The method as in claim 4, wherein a film deposition rate produced by
2 the second current density is less than 0.01 times as great as an average film
3 deposition rate during the thirdly biasing and the succession of steps.
- 1 6. (Currently Amended) The method as in claim [[3]] 1, wherein the first biasing, the
2 secondly biasing, and the thirdly biasing are carried out in-situ.
- 1 7. (Currently Amended) The method as in claim [[3]] 1, wherein the first current
2 density lies within a range of 0.003 to 0.08 amps/cm² and the third current density lies
3 within a range of about 0.003 to 0.08 amps/cm².
- 1 8. (Original) The method as in claim 1, wherein the second current density is no
2 greater than 0.0016 amps/cm².
- 1 9. (Original) The method as in claim 8, wherein the secondly biasing takes place for
2 a time of 1 to 30 seconds.
- 1 10. (Original) The method as in claim 1, wherein the second current density
2 produces a film deposition rate no greater than 45 Å/minute.
- 1 11. (Original) The method as in claim 1, wherein the first biasing takes place for a
2 first time of 1 to 15 seconds and the secondly biasing takes place for a second time of 1
3 to 30 seconds.
- 1 12. (Original) The method as in claim 1, wherein the metal ions are copper ions and
2 the metal layer comprises copper.
- 1 13. (Original) The method as in claim 1, wherein the surface includes an upper
2 portion and an opening extending downwardly therefrom and the biasing the wafer
3 negatively produces the metal layer substantially completely filling the opening.

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1 14. (Original) The method as in claim 13, wherein the opening is a via that includes a
2 width no greater than 0.25 microns.

1 15. (Original) The method as in claim 1, wherein the electrolytic solution is in a bath
2 and includes a flow rate of 5-20 liters per minutes.

1 16. (Original) The method as in claim 1, wherein the electrolytic solution includes an
2 accelerator having a concentration of about 1-16 milliliters/liter and a suppressor having
3 a concentration of about 1-10 milliliters/liter.

1 17. (Original) The method as in claim 1, further comprising depositing a seed layer
2 on the surface prior to the biasing.

1 18. (Currently Amended) A method of electrochemically depositing a metal layer on a
2 wafer, the method comprising:

3 depositing a seed layer on a surface of the wafer;

4 electroplating the metal layer on the wafer by:

5 first immersing the wafer in a first electrolytic solution containing metal ions and
6 first biasing the wafer negatively with respect to the first electrolytic solution so as to
7 create a first current flow and a first current density, the first immersing being the initial
8 step in the electroplating;

9 then immersing the wafer in a second electrolytic solution that contains metal
10 ions and secondly biasing the wafer negatively with respect to the second electrolytic
11 solution so as to create a second current flow and a second current density, the second
12 current density being greater than zero and less than the first current density; and

13 then immersing the wafer in a third electrolytic solution that contains metal ions
14 and thirdly biasing the wafer negatively with respect to the third electrolytic solution so
15 as to create a third current flow and a third current density, the third current density
16 being greater than the ~~second~~ first current density.

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1 19. (Original) The method as in claim 18, wherein immersing the wafer in a second
2 electrolytic solution takes place for a time of 1 to 30 seconds and includes the second
3 current density being no greater than 0.0016 amps/cm².

1 20. (Cancelled)

1 21. (Previously Presented) A process recipe for electroplating a metal film onto a
2 wafer by a continuous electrochemical deposition operation, comprising a first step with
3 a first bias to create a first current density between the substrate and an electrolytic
4 solution, a second step following the first step and having a second bias to create a
5 second current density between the substrate and the electrolytic solution, the second
6 current density being greater than zero and less than the first current density, and
7 subsequent steps of continuously increasing current densities beginning with a third
8 step that follows the second step and has a third bias that creates a third current density
9 between the substrate and the electrolytic solution, the third current density being
10 greater than the first current density, and the first step being the initial step in the
11 continuous electrochemical deposition operation.

1 22. (Original) The process recipe as in claim 21, wherein the second current density
2 is no greater than 0.0016 amps/cm² and produces a deposition rate less than about 50
3 Å/minute.

1 23. (Original) The process recipe as in claim 21, wherein the second step includes a
2 time of 1 to 30 seconds, the first current density lies within a range of 0.003 to 0.08
3 amps/cm² and the third current density lies within a range of about 0.003 to 0.08
4 amps/cm².